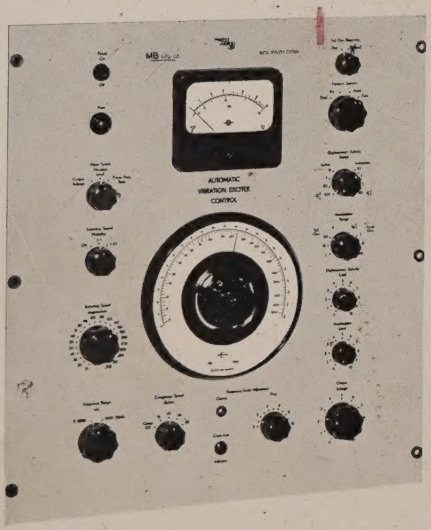
# INSTRUCTION MANUAL




## N 570 . N 571

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# Automatic Vibration Exciter Control

Type N 570 . N 571

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# Introduction.

Mechanical vibrations in a construction occur whenever a change in the forces applied to it takes place. This change in the applied forces can have a periodic or non-periodic character. If the change in forces, the rate of change, or the number of force cycles applied are great enough, the construction might be damaged. The purpose of vibration testing is to determine the damaging effects of vibrations on a structure and thereby enable a redesign to prevent such damage from taking place under the normal operation conditions.

The importance of vibration testing is a function of the severity of damage caused by a break-down, and has been fully recognized in recent years.

As long as only simple structures are to be considered, it is possible to calculate the effects of vibrations. However, as the structure becomes more and more complicated and the operating conditions more and more complex and severe, the amount of calculation involved is large. In such cases, vibration testing may be the only practical solution to the problem of determining vibrational effects.

This is especially true in the aircraft and missile field, where not only the periodic changes in force caused by the engines, but also the forces due to air stream turbulances, play an important role. Also gas turbine parts and parts of other fast running machinery are now normally subjected to vibration testing before the final design of the part is approved.

The vibration test may be carried out in different ways, of which the three most important are:

the shock test,
the random motion test, and
the frequency sweep test.

For the design engineer the frequency sweep test is, in the vast majority of cases, the most preferable method, because the natural frequencies of the object under test as well as their Q-values are directly measured.

The frequency sweep test itself is carried out by feeding a vibration exciter with a certain amount of power at a slowly changing frequency. Due to resonances in the test object and the vibration exciter system, the power necessary to vibrate the test object at a certain constant level is not, however, independent of the frequency. To keep the vibration level constant, the output from a vibration pick-up (signal gen. coil) built into the shaker or mounted on it, is used to control the input power to the vibration exciter.

Normally, the control of the vibration level is made in such a way that when the vibration level of the table tends to increase, which would cause the output voltage from the control pick-up to increase, the input power to the vibration exciter is automatically decreased until status quo is regained.

The time interval from the increase in vibration level (felt by the control pick-up) to the decrease in the input power to the vibration exciter is, although very small, not negligible. This time constant, or in other words "regulation speed", should be selected according to the expected Q-values of the system resonances and the scanning speed chosen for the frequency sweep, i.e. the regulation speed must be greater than the speed with which the system resonances are build up.

To determine which of the three vibrational quantities, acceleration, velocity, or displacement is the most important, with respect to structural damages in the test object, a series of environmental tests have been carried out in the United States. The result of these tests shows that at lower frequencies the occurance of structural damages are most likely to be proportional to the displacement level of the vibrations, whereas at higher frequencies the damages will depend upon the acceleration level.

Vibration tests are therefore often carried out at constant displacement level at low frequencies, and at constant acceleration level at higher frequencies. The exact frequency of the cross-over from constant displacement operation to constant acceleration operation is stated in the different vibration test specifications, e.g. MIL-E-5272 A a. o., and depends on the conditions under which the test object is supposed to operate in practice.

# Description.

**General.**

The Automatic Vibration Exciter Control Type N 570 is designed as signal source for frequency sweep vibration tests. It is built in a steel cabinet and consists basically of an oscillator, a frequency sweep unit, a vibration meter, an automatic level control, and an automatic displacement acceleration transfer unit.

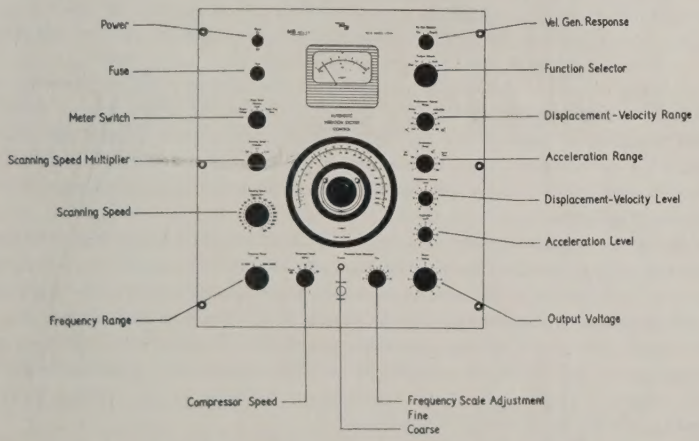


*Fig. 1. Drawing of the Automatic Vibration Exciter Control Type N 570.*

The oscillator is a beat frequency oscillator working on the heterodyne principle with a total frequency range of 5 to 10000 c/s. The frequency range is devided into two parts: one from 5 to 5000 c/s with a true logarithmic scale, and an additional range from 5 to 10 kc/s which is switched in manually.

The frequency sweep unit features a built-in reversible motor for automatic frequency scanning. The frequency range 5 to 5ooo c/s as well as the range 5 to 10 kc/s, or any predetermined part of these ranges, are automatically scanned at a speed which is variable in steps from 3 degrees per minute to 350 degrees per minute (1 frequency decade equals 72 degrees). When the preset frequency limits of the scanning range are reached the motor is automatically reversed, thus traversing the same frequency range with the same speed, but in the opposite direction.

The vibration meter enables easy setting and monitoring of the vibration level in terms of inches (peak to peak), inches/sec. (peak), or g (peak) depending on whether the displacement, the velocity or the acceleration level is kept constant by the automatic level regulation.

The vibration level can be controlled in different ways. When a *velocity type vibration pick-up* or the signal generator coil is used as the controlling element of the shaker table, the following features can be utilized:

1. The Vibration Exciter Control enables the *displacement level* of the shaker table to be kept *constant within the frequency range of 5 to 500 c/s.*
2. The Vibration Exciter Control enables the *acceleration* of the vibrating table to be kept *constant in a frequency range from 10 to 2ooo c/s.*
3. The Vibration Exciter Control enables the *velocity* of the vibrating table to be kept *constant from 5 to 2ooo c/s.*

Employing a built-in automatic switching device it is possible to combine the features mentioned under items 1. and 2. A constant displacement level is then maintained from 5 c/s up to a certain "cross-over frequency" above which the acceleration level of the shaker table is kept constant. The "cross-over frequency" is set by means of a separate control knob on the tuning capacitor spindle.

Using an *accelerometer* with an associated cathode follower as the controlling element on the exciter, the acceleration of the "table" *can be kept constant from 10 to 10ooo c/s.* The actual vibration level can be adjusted in steps and is furthermore continuously variable within each vibration level range.

The regulation speed of the regulating amplifier is variable, providing regulation speeds of 10, 20, 40, and 80 db/sec. This regulation speed is the speed with which a sudden change in operation conditions of the exciter table is regulated back to "normal" conditions.

The maximum output available from Type N 570 is 10 volts across a load of 50 k$\Omega$. This is suitable for most of the many different power amplifiers used in connection with a shaker.

**Description of the Oscillator and Output Amplifier Section.**

The oscillator is built according to the heterodyne principle using two oscillators, one of which operates on a fixed frequency, while the frequency of the other can be varied with a variable capacitor. The fixed oscillator is

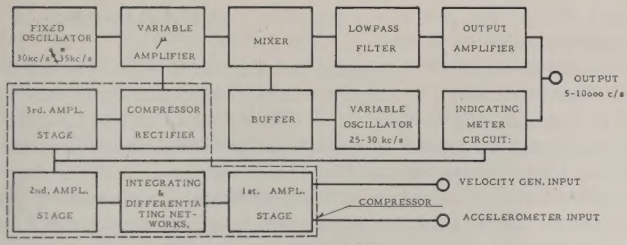


*Fig. 2. Block diagram of N 570.*

tuned to 35 kc/s and is, when the Vibration Exciter Control is switched to the lower of its two frequency ranges, parallelled by an extra capacitor. The frequency is thereby changed to 30 kc/s.

The output voltage from the fixed oscillator is fed to the grid circuit of a pentode, the grid bias of which is controlled by means of the regulating amplifier. The pentode stage is thus working as a variable $\mu$-amplifier. The purpose of this circuit is to control automatically the output voltage of the Vibration Exciter Control by an A.F. control voltage from a vibration pick-up mounted on the shaker table (or from the signal generator coil).

To ensure a low distortion of the output signal from the variable $\mu$-amplifier, a band-pass filter in the form of two inductively coupled circuits is inserted in the anode circuit of the pentode.

The frequency of the variable oscillator can be altered continuously from 30 to 25 kc/s by means of a specially designed variable capacitor. This capacitor is made with a high degree of accuracy, and a maximum deviation of 0.7 degrees from a logarithmic frequency curve is obtained. In the grid circuit of the variable oscillator is inserted two variable capacitors (one coarse and one fine) for adjustment of the Exciter Control frequency. From the oscillator the variable frequency signal is fed to the buffer amplifier, which is inserted to prevent undesired feed-back.

This signal is, together with the signal from the variable $\mu$-amplifier fed to the mixer tube. The tube is of the triode type which provides a low hum level in spite of the a.c. heating of the filament.

In the anode circuit of the mixer tube a low-pass filter with a cut-off frequency of 12 kc/s is inserted, thus passing only the lower frequency, obtained by the frequency conversion, into the output amplifier section. The voltage from the low-pass filter is fed to the control grid of the first tube in the two-stage output amplifier via a variable potentiometer. This potentiometer is operated by the knob marked "Output Voltage" on the front panel of the Vibration Exciter Control and is used for continuous adjustment of the

output voltage. The gain of the amplifier is stabilized by means of a negative voltage feedback.

In the anode circuit of the output tube is, furthermore, inserted a RC high-pass filter. This filter is only switched in when vibration tests are carried out at constant displacement level. The function of the filter is to extend the level range in which full regulation can be obtained for sudden changes in table load. This can be readily understood from the following: when the Vibration Exciter Control is switched to maintain a constant displacement level on the shaker table its output voltage must increase with frequency. If this steady increase in output voltage should be taken care of by the regulating amplifier only, the level range in which a sudden decrease in vibration level could be regulated back to normal level would decrease as the frequency increases. The high-pass filter in the oscillator output circuit will, however, automatically provide an output voltage increase of approximately 6 db per octave up to frequencies around 25 c/s.

**Description of the Regulating Amplifier.**

The function of the regulating amplifier is to control automatically the vibration level of the shaker table which is fed from the Vibration Exciter Control. The output voltage from a velocity type vibration pick-up (or an accelerometer mounted on the table) is fed to the input of the regulating amplifier. Two input terminals are available, one of which should be used in connection with a velocity pick-up (or signal generator coil), and the other when an accelerometer is employed as the controlling element. A switch on the front panel marked "Function Selector" determines which type of regulation actually takes place.

*Using a velocity pick-up* any of the four positions of the "Function Selector" may be used. In the positions "Displ." or "Vel.", the pick-up signal is fed to the "Function Selector" via the 20 db steps input attenuator marked "Displacement-Velocity Range". Constant displacement operation may then be obtained in the range 5—500 c/s, and constant velocity operation from 5 to 2000 c/s. In the position "Accel." that part of the "Acceleration Range" attenuator marked "Vel. Gen." is inserted between the input terminal and the "Function Selector". Constant acceleration operation can then be obtained from 10 to 2000 c/s. In the position "Auto" the "Function Selector" is coupled to a relay operated change-over switch, which switches between the two above mentioned input attenuators.

*Using an accelerometer* as controlling element, the input terminal marked "Accel. Gen. Input" should be used. In this case the allowed positions of the "Function Selector" are reduced to "Accel." and "Auto", and the input-attenuator in use is the "Accel. Gen." section of the "Acceleration Range" switch.

From the "Function Selector" switch the control signal is fed to the regulating amplifier. It consists of three stages, each stage containing a tube of the

double triode type. The first amplifier stage is supplied with a great amount of negative feedback (mixed current and voltage feedback) and is actually used as a vibration pick-up preamplifier, keeping the signal-to-noise ratio as high as possible.

The output from the first amplifier stage is fed to the second amplifier stage via the differentiating and integrating networks necessary to obtain the desired type of regulation. Using the regulating amplifier for velocity control employing a velocity type pick-up or for acceleration control with an accelerometer as controlling element, the voltage is fed directly from the first to the second stage. Employing a velocity type pick-up, the output signal, which is proportional to the velocity level of the shaker, must be differentiated once with respect to time to make the control signal proportional to the acceleration, and integrated once to make the control signal proportional to the displacement. When it is desired to keep the acceleration level of the shaker constant, the differentiating network must consequently be switched in, and to keep the displacement level constant the integrating network is used. In fig. 3 is seen the frequency characteristic of the regulating amplifier switched for displacement control using a velocity pick-up. It is seen that the regulating amplifier sensitivity at 5 c/s is 40 db above the sensitivity at 500 c/s. Operat-

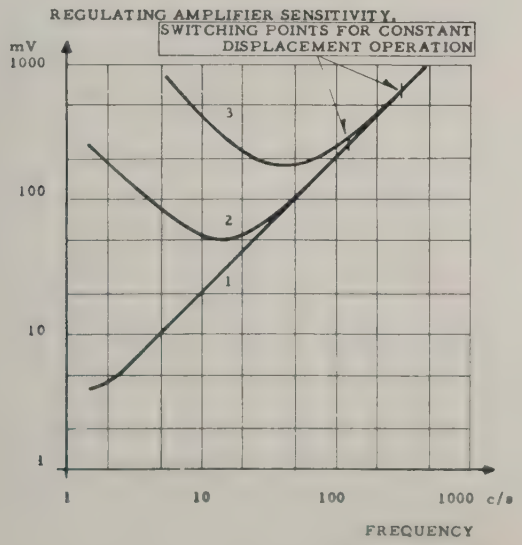


*Fig. 3. Frequency characteristics of the regulating amplifier (compressor) for displacement control using a velocity pick-up as controlling element*

ing at frequencies around 500 c/s, a small low frequent disturbance may consequently cause the closed-loop system to oscillate at a low frequency. To improve the stability, the frequency characteristic is automatically changed into curve 2 and curve 3, when the frequency range is scanned. This is done by means of a switch (N 3) connected to the capacitor spindle.

The second amplifier stage is also supplied with negative feed-back which can be changed by means of the switch marked "Vel. Gen. Response". When this switch is in the position "Flat", the frequency characteristic of the amplifier stage is flat, and when in position "Shaped", the frequency characteristic is corrected to compensate for the frequency drop of the MB velocity pick-ups Type 124 or 126. The output signal from the second amplifier stage may, by means of the switch marked "Meter Switch", be fed directly to the meter, which then indicates the vibration level. Between the second and the third amplifier stage are inserted the potentiometers marked "Displacement-Velocity Level" and "Acceleration Level" for continuous regulation of the vibration level.

The third amplifier stage consists of an ordinary amplifier and phase inverter, the output voltage of which is rectified in a double diode, average type rectifier. The time constant of the rectifier circuit is made variable, and the rectified voltage is used to control the working point of the variable $\mu$-amplifier in the oscillator circuit, thus regulating the oscillator output voltage. By changing the time constant of the rectifier filtering network, the speed with which regulation of the Automatic Vibration Exciter Control output takes place can be varied. This is carried out employing the switch marked "Compressor Speed", and regulation speeds of approximately 10 - 20 - 40 or 80 db/sec. are available. The regulation speed is, furthermore, a function of the amount of feed-back (the compression).*)

During vibration tests the highest possible regulation speed should be used to prevent dangerous vibratory amplitudes in the system from being built up. However, when working at low frequencies and high compressor speeds, the compressor tends to regulate the wave form of the sinusoidally varying output signal from the Automatic Vibration Exciter Control itself, which causes the distortion of the signal to increase. To keep the distortion smaller than 0.5 % under normal operation conditions, a table has been introduced in the operation procedure stating the frequency "limits" for different settings of the "Compressor Speed" knob.

A further arrangement, which should be mentioned in connection with the regulating amplifier, is the automatic cross-over arrangement. It consists of a number of relays, which are operated in the following way:

With the switch marked "Function Selector" in position "Auto", the tuning capacitor is set to the desired cross-over frequency, and the extra knob on

*) (For further information regarding the dynamic regulation the reader is referred to the Brüel & Kjær Technical Review No. 2 - 1958).

the capacitor spindle turned until the lamp marked "Cross-over Indicator" just lights. At the same time the switching of the relays can be heard. The vibration level must now be adjusted in such a way that no sudden change in level takes place when the Vibration Exciter Control is automatically switched from supplying a constant displacement level to a constant acceleration level to the shaker table. In fig. 4 the different possible cross-over points are shown as a function of frequency.

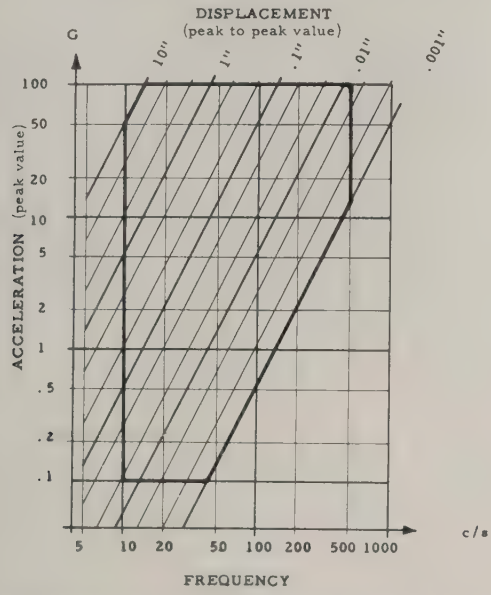


*Fig. 4. Diagram showing the possible cross-over points as a function of frequency. All values within the thick lines can be used.*

The Automatic Vibration Exciter Control features, furthermore, the possibility of mounting an x-potentiometer on the capacitor spindle for x y recording. The shaft diameter of the employed potentiometer should be $\frac{1}{4}$ inch.

When both a velocity pick-up as well as an accelerometer are employed, the velocity pick-up can be used to the control of the displacement level, i.e. below the cross-over frequency, while the accelerometer is used as controlling element above this frequency. The difference between the two methods of controlling the acceleration level above the cross-over frequency is that a velocity pick-up can only be used for acceleration control up to 2000 c/s, whereas the accelerometer enables constant acceleration operation up to 10000 c/s.

**Description of the Frequency Sweep Unit.**

The motor in the Automatic Vibration Exciter Control is a small squirrel-cage motor with four poles, which two by two are connected in series. The two pole-pairs are again connected to the power supply in parallel, with a phase-shift capacitor in series with one of the pole-pairs. The reversing switch switches this series capacitor from the one pole-pair to the other and reverses in this way the motor. The approx. 1460 r/min. of the motor is by means of a mechanical gear reduced to $\frac{350}{360}$ r/min. of the capacitor spindle. By means of the switch marked "Scanning Speed Multiplier", a magnetic clutch operated gear with a transmission factor of 1 : 10 may be switched in. To adjust the scanning speed in smaller steps, an adjustable DC current is fed to the four magnetizing coils. With respect to the DC-current, the motor is working as a short-circuited DC generator, and a breaking torque is produced. The DC current is adjustable by means of a variable series resistor marked "Scanning Speed degrees/min.".

All the switching contacts in the frequency sweep unit are, furthermore, supplied with spark absorbers to prevent the development of electrical pulses which would be picked-up by the compressor amplifier, and cause false regulation to take place.

# Operation.

**General.**

The Automatic Vibration Exciter Control Type N 570 is specially designed to be controlled directly from a velocity type of vibration pick-up having a sensitivity of 95 mV sec./inch. or from an accelerometer with associated cathode follower the sensitivity of which should be 1.41 mV/g (both sensitivities are specified in peak voltage and peak vibration unit), or a combination of both of the above mentioned types of pick-ups. Using pick-ups with the sensitivities specified, the meter provides direct readings on the acceleration, displacement, or velocity scales. However, if an accelerometer and cathode-follower combination is used with a sensitivity other than 1.41 mV/g, it is necessary to use a capacitor output standardizer (such as the ENDEVCO type 2614 amplifier) with the accelerometer or to vary the cathode-follower output to achieve the required sensitivity. Before measurements are carried out, however, the voltage adjuster at the rear of the instrument should be set to the value of the line voltage, the instrument connected to the power supply and its frequency scale properly adjusted.

**Calibration.**

For control knob identification see fig. 1. Make sure that the shaker is not energized during calibration.

The calibration procedure itself should be carried out as follows:

1. Turn the toggle switch marked "Power" to "On". Allow two minutes warm-up time.
2. Set "Meter Switch" in position "Power Freq. Beat".
3. Set the "Scanning Speed Multiplier" in position "Off".
4. Set the knob marked "Frequency Range" to "5—5000 c/s".
5. Set "Compressor Speed" switch on "Comp. Off".
6. Produce a suitable deflection on the instrument meter by means of the knob marked "Output Voltage" (more than center scale reading).
7. Turn the "Oscillator Frequency Dial" so that the pointer points at a frequency equal to that of the line voltage. The instrument meter pointer will now start fluctuating.
8. Turn the "Frequency Scale Adjustment" knob marked "Fine" until the fluctuations on the meter become slower and finally almost cease. The fluctuations begin again when the critical point is passed. If the adjustment knob "Fine" does not give a satisfactory regulation, the screwdriver operated capacitor marked "Coarse" should be adjusted.

9. Set the frequency dial pointer to a frequency equal to 1/5 of the mains voltage frequency and repeat item 8.

The instrument is now ready for use.

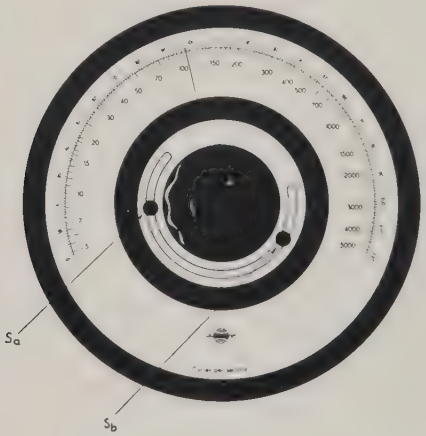


*Fig. 5. Frequency Dial of Type N 570.*

**Adjustment of the Automatic Frequency Scanning Arrangement.**

1. Loosen the screws on the "Oscillator Frequency Dial" marked $S_a$ and $S_b$ on fig. 5.
2. Turn the "Oscillator Frequency Dial" pointer to the low frequency limit of the range in which it is desired to take measurements, and move the screw $S_a$ counter clockwise until it is stopped by the contact arm of the microswitch. Fasten $S_a$ in this position.
3. Turn the "Oscillator Frequency Dial" clockwise until the pointer points at the highest frequency at which measurements are to be taken. Then move the screw $S_b$ clockwise until it is stopped by the contact arm of the microswitch. Fasten $S_b$ in this position.
4. Set the "Scanning Speed" knob to the desired value, and switch on the frequency sweep by turning the "Scanning Speed Multiplier" to "X 1" or "X 0.1" depending upon the speed chosen for the sweep).

The selected frequency range will now be swept automatically. When the preset limits of the range are reached, the rotation of the motor is reversed and the same frequency range will be traversed with the same speed, but in the opposite direction.

The correct setting of the "Scanning Speed" knob is easily calculated: If it is

desired to scan the frequency range $f_1 - f_2$ $f_1$ in T minutes the settings of the "Scanning Speed" knob is found from

$$S = \frac{2\,(d_2 - d_1)}{T},$$

where $d_2$ and $d_1$ are the degrees corresponding to the frequencies $f_2$ and $f_1$, respectively. These values can be read directly off the frequency dial. In other words, the scanning speed is the total scanning range in degrees divided by the desired scanning time.

**Operation Using a Velocity Type Vibration Pick-up as the Controlling Element.**

When used with a velocity type of pick-up only, the following automatic control of the shaker table is possible:

a. The displacement level of the shaker table can be kept constant within the frequency range 5 to 500 c/s.

b. The velocity level of the table can be kept constant within the frequency range 5 to 2000 c/s.

c. The acceleration level of the table can be kept constant within the frequency range 10 to 2000 c/s.

d. The displacement level of the shaker table can be kept constant from 5 c/s and up to a certain "cross-over" frequency. From the "cross-over" frequency and up to 2000 c/s the acceleration level of the table can be kept constant, the "crossing-over" itself being taken care of by an automatic switching device. The frequency range in which an automatic "cross-over" can be established will depend upon the vibration levels employed for the test, and can be determined by means of fig. 4.

**a. Operation at Constant Displacement Level.**

Apply the following procedure:

1. Calibrate the instrument as described under Calibration, see page 13.
2. Adjust the automatic frequency scanning arrangement, see page 14.
3. Set the knob marked "Output Voltage" to "0".

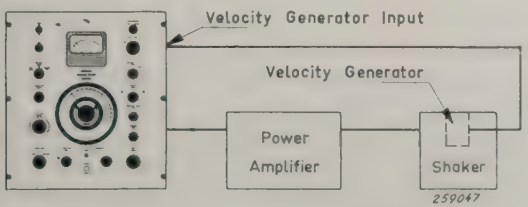


*Fig. 6. Arrangement for vibration control using a velocity pick-up.*

4. Turn the knobs marked "Displacement-Velocity Level" and "Acceleration Level" to "0".
5. Connect the instrument as shown in fig. 6.
6. Set "Meter" switch in position "Vibration Level" and "Vel. Gen. Response" to "Flat" when a velocity pick-up with flat frequency response characteristic is used, and to "Shaped" when the velocity pick-ups Type 124 or 126 are used.
7. Set "Frequency Range" switch to 5—5000 Hz.
8. Set the knob marked "Compressor Speed" according to the following table, (see also page 10):

| Lowest Frequency of the desired Sweep Range | "Compressor Speed" Knob Setting |
|---|---|
| 70 c/s | 80 db/sec. |
| 30 c/s | 40 db/sec. |
| 15 c/s | 20 db/sec. |
| lower than 15 c/s | 10 db/sec. |

9. Set "Function Selector" to "Displ.".
10. Set "Displacement-Velocity Range" to the desired displacement level range (marked "0.01", "0.1", "1", "10" "inches").
    *NOTE:* The figures "0.01", "0.1", "1", and "10" indicate full scale meter deflection peak-to-peak displacement level in inches.
11. Turn the "Output Voltage" knob to maximum.
12. Turn the gain of the *power amplifier* slowly to maximum.
13. Set the Oscillator Frequency Dial" at any frequency between 5 and 500 c/s.
14. Turn the knob marked "Displacement-Velocity Level" clockwise until the instrument meter pointer indicates the desired vibration level.
15. Set "Meter Switch" in position "Output Voltage".
16. Adjust the gain control of the *power amplifier* so that the max. output voltage required from the Vibration Exciter Control during a complete frequency sweep is 10 Volts. (The scanning of the desired frequency range should be carried out manually and very slowly).
17. Set "Meter Switch" in position "Vibration Level". The instrument is now ready for use.

**b. Operation at Constant Velocity Level.**

Apply the following procedure:

1. Follow instructions item 1 through 8 under "Operation at Constant Displacement Level". (Page 15).
2. Set "Function Selector" to "Vel.".
3. Set "Displacement-Velocity Range" to the desired velocity level range (marked "0.1", "1", "10", "100" "inches/sec.").

*NOTE:* The figures "o.1", "1", "10", and "100" indicate full scale meter deflection peak value velocity levels in inches/sec.

4. Turn the "Output Voltage" knob to maximum.
5. Turn the gain of the *power amplifier* slowly to maximum.
6. Set the "Oscillator Frequency Dial" at any frequency between 5 and 2000 c/s.
7. Follow instructions item 14 through 17 under "Operation at Constant Displacement Level". (Page 16).

**c. Operation at Constant Acceleration Level.**

Apply the following procedure:

1. Follow instructions item 1 through 8 under "Operation at Constant Displacement Level". (Page 15).
2. Set "Function Selector" to "Accel.".
3. Set "Acceleration Range" to the desired acceleration range using the "Vel. Gen." part of the switch.

*NOTE:* The figures "1", "10", and "100" indicate full scale meter deflection peak value acceleration levels in multiplies of g (Acceleration of gravity).

4. Turn the "Output Voltage" knob to maximum.
6. Set the "Oscillator Frequency Dial" at any frequency between 10 and 2000 c/s.
7. Turn the knob marked "Acceleration Level" clockwise until the instrument meter pointer indicates the desired vibration level.
8. Follow instructions item 15 through 17 under "Operation at Constant Displacement Level". (Page 16).

**d. Operation at Constant Displacement/Constant Acceleration Level.**

The adjustments to be carried out, when it is desired to keep the displacement level of the shaker table constant at frequencies below a certain "cross-over" frequency, and the acceleration level of the table constant at frequencies higher than the "cross-over", may be carried out in different ways. However, a convenient method based on the operation procedures described under *a* and *c* will be given in the following:

1. Follow instruction item 1 through 12 under "Operation at Constant Displacement Level". (Page 15).
2. Set the "Oscillator Frequency Dial" to the desired "cross-over" frequency.
3. Turn the knob marked "Displacement-Velocity Level" clockwise until the instrument meter pointer indicates the desired vibration level.
4. Set "Meter Switch" in position of "Output Voltage".
5. Adjust the gain control of the *power amplifier* until the meter pointer on the Vibration Exciter Control points at 10 dB (lower meter scale).
6. Set the "Function Selector" to "Accel.".
7. Set "Acceleration Range" to the desired acceleration range using the "Vel. Gen." part of the switch. (See also fig. 4).

8. Turn the knob marked "Acceleration Level" clockwise until the instrument meter pointer points at 10 db.
9. Set "Function Selector" to "Auto".
10. Keep the "Oscillator Frequency Dial" pointer in its position, i.e. pointing exactly at the desired "cross-over" frequency, and turn the outer knob until the red lamp marked "cross-over" indicator just lights up.
11. Adjust the gain control of the *power amplifier* so that the max. output voltage required from the Vibration Exciter Control during a complete frequency sweep is 10 Volts. (The scanning of the desired frequency range should be carried out manually and very slowly).
12. Set "Meter Switch" to Vibration Level.

**Operation Using an Accelerometer as the Controlling Element.**

In cases where it is desired to keep the acceleration level of the table constant at frequencies higher than 2000 c/s an accelerometer should be used as the controlling element of the shaker.

If the accelerometer used is of the piezo-electric type, a cathode follower stage should be inserted between the accelerometer itself and the input of the regulating amplifier in the Vibration Exciter Control. This circuit will, when correctly designed, ensure the low-frequency cut-off of the accelerometer to be lower than 5 c/s.

The following operation procedure might be applied:

1. Calibrate the instrument as described under "Calibration", see page 13.
2. Adjust the automatic frequency scanning arrangement, see page 14.
3. Set the knob marked "Output Voltage" to "0".
4. Turn the knobs marked "Displacement-Velocity Range" and "Acceleration Range" to "0".
5. Connect the instrument as shown in fig. 7.

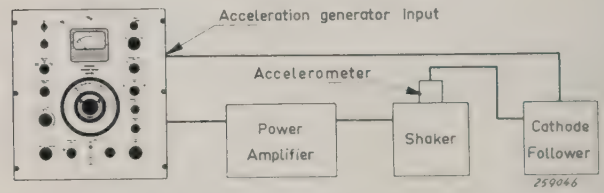


*Fig. 7. Vibration test arrangement using an accelerometer as the controlling element.*

6. Set "Meter Switch" in position "Vibration Level".
7. Set "Frequency Range" switch to the desired frequency range.

8. Set the knob marked "Compressor Speed" according to the following table:

| Lowest Frequency of the desired Sweep Range | "Compressor Speed" Knob Setting |
|---|---|
| 70 c/s | 80 db/sec. |
| 30 c/s | 40 db/sec. |
| 15 c/s | 20 db/sec. |
| lower than 15 c/s | 10 db/sec. |

9. Set "Function Selector" to "Accel.".
10. Set "Acceleration Range" to the desired acceleration range using the "Accel. Gen." part of the switch.

    *NOTE:* The figures "1", "10", and "100" indicate full scale meter deflection peak values acceleration levels, in multiplies of g.
11. Turn the "Output Voltage" knob to maximum.
12. Turn the gain control of the *power amplifier* slowly to maximum.
13. Set the "Oscillator Frequency Dial" at any frequency between 10 and 10000 c/s.
14. Turn the knob marked "Acceleration Level" clockwise until the instrument meter pointer indicates the desired vibration level.
15. Set "Meter Switch" in position "Output Voltage".
16. Adjust the gain control of the *power amplifier* so that the max. output voltage required from the Vibration Exciter Control during a complete frequency sweep is 10 Volts. (The scanning of the desired frequency range should be carried out manually and very slowly).
17. Set "Meter Switch" in position "Vibration Level". The instrument is now ready for use.

**Operation Using Both Velocity Pick-up and Accelerometer as Controlling Elements.**

If desired, the combination of a velocity pick-up and an accelerometer may be used to control the movements of the shaker table. This combination makes the following operation conditions possible:

a. The acceleration level of the shaker table can be kept constant in the frequency range 10 to 10000 c/s, employing the accelerometer as the controlling element. For operating instructions see "Operation Using an Accelerometer as the Controlling Element".

b. The velocity level of the table can be kept constant in the frequency range 5 to 2000 c/s, employing the velocity pick-up as the controlling element. This type of control has been described under "b. Operation at Constant Velocity Level" page 16.

c. The displacement level of the shaker table can be kept constant at frequencies below a certain, predetermined "cross over" frequency using the velocity pick-up as the controlling element. At frequencies higher than

the "cross-over" the acceleration level can be kept constant employing the accelerometer to control the movement of the table.

The operation procedure to be applied in this case will be a combination of the already outlined procedures.

# Specification.

## Oscillator Section

**Frequency Range:** 5—5000 c/s and 5—10 kc/s.
**Frequency Scale:** Logarithmic from 5—5000 c/s.
**Frequency Accuracy:** 1 % ±0.25 c/s.
**Output Voltage:** Max. 10 volts.
**Max. Load:** 50 kΩ.
**Output Voltage Accuracy:** Better than ± 0.5 decibel in the frequency range 5—5000 c/s and better than ± 1 decibel for frequencies between 5 and 10000 c/s.
**Waveform:** Max. distortion in the frequency range 5—10000 c/s 0.5 % without compressor. Max. distortion with compressor 0.5 % for higher frequencies, and 1 % for 10 c/s at the lowest compressor speed.
**Hum Voltage:** At least 65 decibel below full output.
**Scanning Speed:** Variable in 44 steps from 3.1 to 350 degrees per minute.
**Frequency Limit Controls:** Front panel set screw adjustment.
**Automatic Cross-over Control:** Cross-over frequency may be adjusted over the frequency range 10—500 c/s.

## Vibration Meter Section

*1. Velocity pick-up as controlling element.*

**Displacement Ranges:** Full scale readings 0.01", 0.1", 1", and 10". Accuracy ± 4 % from 10—500 c/s. Usable range 5—500 c/s.
**Acceleration Ranges:** Full scale readings 1g, 10g, and 100g. Accuracy ± 4 % from 20—2000 c/s. Usable range 10—2000 c/s.*)
**Velocity Ranges:** Full scale readings 0.1 in./sec., 1 in./sec., 10 in./sec., and 100 in./sec. Accuracy ± 4 % from 5—2000 c/s.
**Pick-up Sensitivity:** The vibration meter is adjusted for a velocity pick-up output of 95 mV sec. per inch. (Peak value volts and peak value velocity).
**Input Impedance:** 111 kΩ.
**Meter Scale:** Semi logarithmic.

*) Due to a tendency of overloading the 1st amplifier stage in the regulating amplifier section at lower frequencies, the tolerance ± 4 % at 10 c/s is only correct for instrument deflections smaller than 15 db, and the maximum usable deflection is 17 db

2. *Accelerometer with Cathode follower as controlling element.*

**Acceleration Ranges:** Full scale readings 1g, 10g, and 100g. Accuracy ± 4 % from 10—10000 c/s.

**Pick-up Sensitivity:** The vibration meter is adjusted for an accelerometer output of 1 mV per g. (RMS value volts and peak value acceleration).

**Input Impedance:** 111 k$\Omega$.

## Compressor Section

**Frequency Range:** 5—10000 c/s.

**Regulation Speeds:** 10—20—40—80 decibel per second.

**Dynamic Range:** 45 db. 20 db can be compressed to 0.5 db and 40 db can be compressed to 1.5 db.**)

## General

**Power Supply:** 115—127—150—220 and 240 volts. 50 c/s or 60 c/s. (Specify when ordering).

**Tubes:** 2 × 6AU6 (EF94), 5 × 12AT7 (ECC81), 6AL5 (EAA91), 12AX7 (ECC83), 6X4 (EZ90), OA2, OB2.

**Dimensions:** 53 (height × 48 (width) × 22 (depth excl. dials and knobs) centimetres.

21 (height) × 19 (width) × 8½ (depth) inches.

**Weight:** 28 kg - 62 lbs.

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**) Using a velocity type pick-up as controlling element for acceleration control at lower frequencies, the sensitivity of the regulating amplifier at higher frequencies is very high. This may cause the tube-noise from the tube in the 1st amplifier stage to interfer with the low frequency signal. To keep a sufficiently high signal to noise ratio, the maximum usable compression for the type of operation is

45 db at 50 c/s
40 db at 20 c/s
35 db at 10 c/s

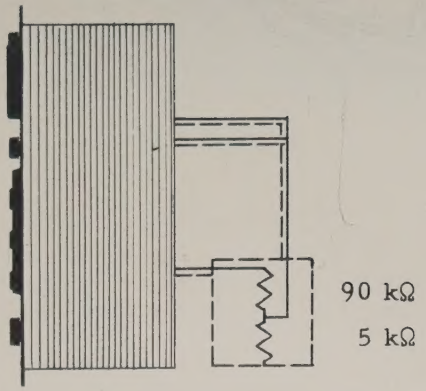
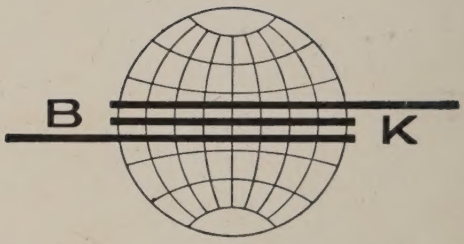



*Fig. 1. N 570 connected for checking purposes.*

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